

3 Survey Equipment

Procurement and maintenance of surveying equipment, tools and supplies are important parts of the Caltrans survey effort. Proper use, storage, transportation and adjustment of equipment are major factors in the successful completion of a survey.

This Section provides policy, procedure and general information on procurement, control and maintenance of survey equipment, tools and supplies.

3.1 Policy Concerning Personal Use of State Property

Any State employee who misuses State equipment or property is subject to adverse action. Misuse includes taking State equipment or property without authorization, damaging or losing it through lack of care, or using it for personal business.

3.2 Procurement of Equipment and Supplies

Refer to the *Acquisition of Materiel Manual* published by the Caltrans Division of Procurement and Contracts (DPAC) for complete information on ordering and purchasing supplies, equipment, and other commodities.

3.2-1 Use of Purchase Request Form

Except in emergencies, acquisition of equipment, whether from a State warehouse or an outside vendor, is initiated with a Caltrans Purchase Request Form (ADM-1415) properly filled out and directed to the DPAC.

Purchase Requests must be approved by and include the signature of either the Deputy Director, District Director, Division Chief, the Resource Manager or their designee (Office Chief, Branch Chief, etc.).

Completed Purchase Requests are submitted to the DPAC. The DPAC determines the proper method for obtaining equipment and supplies. Consulting with the DPAC before completing the Purchase Request and/or using “on-line” ordering with digital forms and the Caltrans network can reduce procurement time.

3.2-2 Sources of Supply

The following prioritized sources should be considered for supplies. DPAC can help you determine which source is most appropriate.

Local Inventory: Always check supplies on hand before placing orders.

District Warehouse: Review the District Warehouse (or Stockroom) catalogs for items needed.

Surplus Elsewhere in the District (or in another District): A reasonable effort must be made to utilize excess stock within the District before purchasing additional items.

DPAC Warehouse: The DPAC Warehouse provides supplies for the daily operating needs of the Department and stocks a wide variety of items in its warehouse in Sacramento. The warehouse stocks most common surveying supplies and equipment such as rods, steel tapes, paint, flagging, stakes, nails, shiners, etc. It also stocks Caltrans manuals, publications and forms. Some districts have direct access to the DPAC through the Caltrans network. Check with the DPAC for direct access questions.

Department of General Services (DGS) – Materiel Services: Materials not available from the DPAC Warehouse must be ordered from this source, if available. Examples of the DGS Materiel Services Warehouse inventory are: State forms, janitorial products and publications.

Prison Industry Authority (PIA): Some items produced by PIA include orange coveralls, shirts, vests, other apparel items, work gloves, safety glasses and office furniture. PIA publishes a product catalogue. Prior to commercial procurement of items similar to those produced by PIA, a written waiver must be obtained from PIA.

State Contracts: Statewide contracts are awarded by competitive bid for certain volume commodities. Except in emergency situations, purchases of contract commodities cannot be made from outside sources.

State Price Schedules, California Multiple Award Schedules (CMAS) or

California State Computer Stores: Some commodities can be ordered from suppliers who have negotiated agreements with the Division of Engineering Services (DGS) to supply products at a guaranteed price. These programs are optional but purchasing equipment under \$15,000 through CMAS or the State Computer Store can be done without using the DGS formal bid process. Contact the DPAC for advice on using these programs.

Outside Vendors: Materials not available from the above-named sources can be purchased using Purchase Orders or Cal-Card Visa. DGS has delegated a general purchase authority of up to \$15,000 to the Department. Purchases over the \$15,000 limit require a formal DGS bid process. For purchases over the limit, consult with the DPAC and consider using CMAS or the State Computer Store.

3.2-3 Caltrans Cal-Card Small Purchase Program

Materials, supplies and services obtained from outside vendors should be purchased using the Caltrans CAL-Card Small Purchase Program as it expedites receipt and payment and reduces paperwork. Purchase limit for the CAL-Card is \$1,000 for purchases and \$999.99 for each service order with a limit of \$5,000 in service orders per year for any one vendor. Cards are issued to individuals, who are responsible for the use of the card. For applications for cards and copies of the “Caltrans CAL-Card Handbook,” contact the DPAC.

3.3 Survey Party Equipment List

The following is a suggested list of equipment, tools, and materials to outfit a typical Caltrans survey crew. This list may be modified when performing nonroutine surveys or when operating in remote locations.

Equipment List for Typical Caltrans Survey Crew

Quantity	Description of Item
1 each.	Electronic Total Station Survey System including data collection device and batteries
1 each	Optical pendulum level
2 each	Calculators with pre-programmed COGO
1 each	Lap-top PC capable of running approved survey software
1 each	Computer printer (portable, ink jet)
1 each	Cellular telephone
5 each	Tripods
5 each	Tribrachs
1 each	Tribrach level bubble adjusting block
1 each	Tribrach optical plummet adjusting cylinder
5 each	Single prism assemblies and stems
2 each	Triple prism assemblies and stems
1 each	Extended-range multiple (11) prism assembly
2 each	Standard extendible prism poles
2 each	4 meter layout/prism poles
3 each	7.5 meter fiberglass rods with prism adapters
1 set.....	Matched geodetic leveling rods
assortment	Fiber and steel tapes (5-25 meter)
4 each	Plumb bobs
2 each	Barometer and thermometer
5 each	District 2 'Zekes' (rubber pucks with slots that hold plastic reflectors for taking pavement shots)
1 each	Rola-Tape wheeled measuring device
1 each	Magnetic field pipe (monument) locator
1 each	"Smart Charge" battery charging/cycling device
3 each	Hand-held 5-watt FM two-way radios
1 each.	Programmable handheld radio with appropriate district surveys and/or region maintenance and construction frequencies
1 each	Telescoping pole saw
assortment	Cutting tools (machetes, axes, hatchets, etc.)
1 each	Camera
1 each	First aid kit (16 unit)
14 each	Traffic cones
12 each	Warning flags
2 each	Hand-held "Stop/Slow" paddles
2 sets	"Survey Crew Ahead" signs

Equipment List for Typical Caltrans Survey Crew, continued

Quantity	Description of Item
1 each	Drinking water cooler (20-liter)
1 each	Traffic accident surveillance & analysis system listing
1 each	District/Region post mile map
1 each	District/Region list of emergency and medical facilities (phone numbers and locations)
assortment	Insect repellent
assortment	Anti-tick release and removal kit
assortment	Safety glasses (gray, amber and clear)
assortment	Ear protection devices
assortment	Gloves (both leather and cloth types)
assortment	Toxic vegetation barrier cream
assortment	Wooden stakes
assortment	Plastic construction staking cards
assortment	Rebar, 760 mm and 460 mm long, with aluminum caps
assortment	Galvanized iron pipe, 760 mm and 460 mm long, with plastic plugs
assortment	Brass caps and brass caps on iron pipes
assortment	Impact tools for brass cap on rebar, and pipe
assortment	Hand tools (hammers, gads, wrenches, etc.)
assortment	Ribbon flagging (various colors)
assortment	Nails (100 d spikes, PKs, etc.)
assortment	Writing materials (pens, pencils, markers, etc.)
assortment	Drafting tools (triangles, templates, acu-Arc, engineering scales, etc.)
assortment	Note forms (grid, survey, etc.)
assortment	Paint (white, orange, black, green, etc.)
assortment	Digging tools (shovels, picks, digging bars, etc.)
assortment	Large clear plastic garbage bags to protect equipment from inclement weather.
1 each	Whisk broom
assortment	Various size die stamping sets
assortment	Hard hat liners and gloves for protection from cold
1 copy each	Surveys Manual; CTDC Manual; CTDAP Manual; Safety Manual; Manual of Traffic Controls; and Chapter 8, "Protection of Workers" of the Maintenance Manual
1 set	Snow chains
1 set	Jumper cables
1 box	Warning flares
2 each	Staplers (gun type for slope stake cards and also standard office stationery type)
assortment	Office and stationery supplies (rubber bands, paper clips, envelopes, etc.)

3.4 Equipment Control Following Acquisition

The *State Administrative Manual* (SAM) governs control of equipment. For information on property control, refer to SAM or contact the District Property Control Unit.

3.4-1 Classes of Property

Equipment, materials, and supplies are categorized as expendable or non-expendable. Expendable is defined as material or equipment normally consumed while in service. Examples of expendable equipment are tools such as shovels and mechanical pencils. Non-expendable material or equipment is not consumed in service and is expected to have a life expectancy of one or more years. Some examples of non-expendable equipment are survey instruments, chain saws, and computers.

Equipment with a value exceeding \$500 is generally assigned a Caltrans “CT” number and tagged by the District Property Control Unit. The CT number on the tag is used to inventory equipment.

3.4-2 Inventory of Equipment

The SAM mandates an accounting of all non-expendable property every three years. This triennial inventory is the responsibility of the District Property Control Unit. To facilitate the triennial inventory, each Surveys Branch should maintain an inventory of all non-expendable equipment and accessories.

The DES/Office of Geometronics maintains a master inventory of all equipment and accessories that it has acquired and issued to the District Surveys Branches. Control of this equipment and its accessories is the responsibility of the District Surveys Engineer and any change in status should be reported to the DES/Office of Geometronics.

3.4-3 Transfers of Non-Expendable Property

Transfer or Loan of Equipment Within the District Surveys Branch: Record keeping for this type of property transfer is very important. If transfers are made without documentation, the person who ships the equipment will remain responsible for it until the paperwork is properly submitted. For this reason all equipment transfers

should be recorded using an Equipment/Non-Expendable Equipment Receiving and Transfer Record (Form DM-E 0098). Copies of the fully-completed DM-E 0098 should be distributed to all involved parties.

Transfers or Loan of Equipment to Other Functions Within District: Loans of surveying equipment to other district functions may be made at the discretion of the District Surveys Engineer. Before any loans are made the District Surveys Engineer should consider employee and public safety as well as overall efficiency of survey operations. Loans of survey equipment should be recorded using form DM-E 0098.

Transfers or Loan of Equipment to Other Districts or State Agencies: The transfer or loan of non-expendable property owned by the Office of Geometronics between districts or between a district and another state agency requires Office of Geometronics approval. No transfer should be undertaken without preparing a Form DM-E 0098.

3.4-4 Disposal of Outdated Equipment

Equipment no longer suitable for use by the Department because it is worn, broken, deteriorated, or obsolete is retired by sale, trade-in, donation to a public entity, or recycling.

Retirement of non-expendable equipment must be authorized by a “Board of Survey” designated by the District Director. In addition, the proposed retirement should first be discussed with the equipment coordinator of the DES/Office of Geometronics. The District Surveys Engineer is responsible for retiring equipment and properly preparing a Request For Property Survey (Form ADM-0395) and submitting it to the District Property Control Branch. DES/Office of Geometronics will initiate retirement of equipment it owns after all necessary data is received from the District Surveys Branch.

3.4-5 Lost, Stolen, or Damaged Survey Equipment

Whenever State-owned equipment is lost, stolen, vandalized or otherwise damaged, the employee assigned the equipment must:

- Except in the case of accidental damage, immediately contact the California Highway Patrol and the law enforcement agency with jurisdiction in the area where the loss occurred.
- Notify the first-line supervisor and the District Security Coordinator.

- Complete a Report of Lost, Stolen, or Damaged State-Owned Property (Form ADM-0396), or its equivalent.

Form ADM-0396 should be carefully filled out. If the form is not immediately available, record the:

- Description of the equipment (make, model, serial number, CT number, etc.) including, if known, original cost or replacement cost with supplementary costs such as shipping and installation.
- Circumstances of the loss, damage, or crime including the date and time.
- Name of employee reporting the loss.
- Highway Patrol or police report number.

The employee should submit the report (or equivalent information) to the employee's first-line supervisor. The first-line supervisor will review, sign and add the following information to the report:

- Acceptability of the report made by the employee.
- Precautions taken to prevent the loss.
- The degree of culpability of the employee and whether negligence was involved.

The final report (ADM-0396) is then sent to the District Surveys Engineer for review before submission to the District Property Branch. If the equipment involved was originally acquired by the Office of Geometronics, a copy of the report should be forwarded to the Office of Geometronics.

Individual Responsibility

Each employee must “reasonably” care for State equipment. The value of lost, stolen, or damaged equipment may be charged to negligent employees.

3.5 Surveying Instruments

Caltrans survey crews are provided state-of-the-art surveying instruments. Following are typical survey instruments used by Caltrans survey crews:

- Total Station Survey System with data collection device and accessories (tripods, tribrachs, prism poles, prisms, batteries).
- Global Positioning System (GPS) receivers with data collection devices, real time radio links, and accessories.
- Leveling Systems (automatic optical pendulum and electronic bar code reading) and accessories.
- Field and office computers.

3.5-1 General

Survey Instrument Operators Manuals

Each instrument is furnished with an operator's manual, a copy of which should be filed in the Surveys office. The manual contains a description of the instrument, specifications, and basic operating instructions along with recommended servicing and adjusting intervals and methods. The operator's manual should be kept with the instrument at all times, and thoroughly studied prior to use of the instrument, particularly when prescribed field checks and adjustments are to be made. Notes collected during adjustment procedures should be included in field notes that will be permanently archived. (See Section 13, "Survey Records.")

Transport and Storage of Survey Instruments

For transport of an instrument by road or air, use shockproof casing or packing materials to protect the instrument from excessive vibration. If at all possible, retain and reuse the original manufacturer's packaging system. Store instruments in a position consistent with the design of its carrying case.

Electrical Power Sources, Use and Maintenance

A DC power source, usually 12 volts, is required to power electronic instruments and data collection units. Batteries are supplied with instruments, but for 12-volt instruments, any source of 12v DC power can be utilized. A clip-on power cable is usually provided for use with an automotive battery. Such cables must have fused protection against reverse polarity.

Survey crews are equipped with a “smart charge” battery charging unit, as well as charging equipment that is supplied with the equipment. The smart charger will diagnose, process, and recharge many types of batteries used by the survey crew.

Select the proper charger provided by the instrument manufacturer or an approved “smart-charge” battery charger, based on the amp-hour rating of the battery. Do not interchange battery chargers.

When completely discharged, ni-cad batteries generally take approximately 16 hours to recharge. To prevent damage to the batteries from overcharging and to correctly recycle avoiding “memory” problems, use “smart charge” battery chargers when possible.

Routine Maintenance and Care of Survey Instruments

Before using an instrument, visually inspect it for damage. Check all machined surfaces including the polished faces of lenses and mirrors. Snug up all clamps and check motions for smooth operation (absence of binding or gritty sounds).

Clean the instrument exterior frequently. Accumulation of dirt and dust can mar machined or polished surfaces and cause friction and sticking in the motions. Remove dust with a camel’s-hair brush, then clean soiled non-optical parts with a soft cloth or with a clean chamois. Clean external surfaces of lenses with a fine lens brush. If necessary, use lens tissue. Do not use silicone treated tissue that can damage coated optics; do not use any liquids other than pure alcohol. If required, lightly fog the lenses by breathing on them. Take care not to scratch lenses or their coating. Never touch optical glass with your fingers. Do not loosen or attempt to clean the internal surface of any lens.

If an instrument has become wet, unpack it at the end of the day and, after wiping dry with a soft towel or cloth, leave the instrument and any of its accessories outside of the case to dry. Also leave the case open to dry. If the foam inserts for the case are wet, also remove them for drying. Do not replace the instrument in the case until completely dry.

Service and Repair of Survey Instruments

Periodic servicing, repair or complex adjustments shall be accomplished by authorized service facilities. Service contracts for maintenance and repair of survey instruments and accessories are negotiated through a competitive bid process and administered by the DES/Office of Geometronics. Instruments covered by a service and repair contract shall not be serviced by any other means. The following Caltrans' survey instruments are generally covered by DES-administered service contracts:

- Total station survey systems and accessories
- Theodolites
- Electronic bar-code level and optical pendulum levels
- GPS receivers and accessories

A copy of each DES-administered contract is provided to each District Surveys Office.

Maintenance Schedules and Record Keeping for Individual Instruments:

Refer to each instrument operator's manual to determine if the manufacturer suggests scheduled service intervals. If there is not a suggested service interval, service should be on an "as-needed" basis. Total stations should be serviced approximately once every two years. All instruments (or accessories) should be serviced when:

- The instrument or accessory is inoperative.
- The instrument or accessory is damaged.
- The instrument or accessory does not maintain adjustment(s).
- Mechanical adjustments are stiff or binding.
- Optics are fogged or cloudy.

Each District Survey Equipment Manager, in conjunction with the District's crew chiefs should maintain records detailing the frequency of service for each survey instrument.

Use of DES-Administered Service Contracts: To service or repair an instrument, call the DES/Office of Geometronics and obtain a work order for the instrument. (Some contracts require an initial call to the contractor to receive a Returned Merchandise Authorization (RMA). Refer to the specific contract.) A shipping address for

the designated service facility will also be furnished. Complete a Survey Equipment Work Order form and include the instrument and accessories serial numbers and CT numbers on the form. Provide a description of problem(s) encountered with the instrument and/or accessories and include specific instructions for requested repair services. Also include the requester's phone number. Distribute copies of the Work Order Form as indicated on the form.

Note: Ship instruments in their transport cases. When possible ship instruments in the original manufacturers' shipping cases. Pack all other instruments and accessories in a sturdy shipping box with adequate cushioning material between their transport case and shipping box.

Service/Repair Limits — Service/Repair Cost vs. Remaining Worth: All DES-administered service contracts specify that written estimates are required if the total cost of service will exceed the contracted limit. If costs exceed the maximum allowable service cost, contact the Office of Geometronics.

Generally, instruments should be retired when estimated service cost exceeds estimated value after service. The determination of when to retire, rather than service an instrument, should be made in consultation with the Office of Geometronics and based on the following factors:

- Cost of servicing.
- Obsolescence of instrument.
- Past service records.
- Availability of parts.
- Availability and cost of new instruments.
- General condition of instrument.
- Make of instrument.

Service/Repair of Other Survey Equipment: Service for survey equipment not covered by DES-administered service contracts may be provided by:

- Manufacturers' warranties.
- Department-wide service contracts.
- Individual service contracts negotiated with a manufacturer or dealer for specific instruments.
- Use of the CAL-CARD credit card for service on an as-needed basis.
- Caltrans or General Services service facilities

Before requesting service/repair of any survey equipment:

- Check manufacturers' warranties.
- Be sure that service does not cost more than replacement.

3.5-2 Total Station Survey Systems (TSSS)

Field components of TSSS systems include:

- Total station
- Data collection system
- Cables
- Accessories (such as tripods, tribrachs, batteries and chargers, stakeout poles, and other miscellaneous accessories)

Total Station

The typical Caltrans total station is composed of an electronic theodolite capable of measuring horizontal and vertical angles to the nearest 1" with a standard deviation of $\pm 0.5''$ and an electronic distance measuring instrument (EDMI), which when used in its standard mode, will measure distances to a standard deviation of $3 \text{ mm} \pm 2 \text{ ppm}$. Expected measuring range of the EDM in average environmental conditions is 2500 m when using a single prism. This instrument may be programmed to perform a variety of automated measurement functions and computations.

Data Collector

Measured values captured by the total station are generally transferred via cable to a data collector and then through the data collector to a computer.

Field Operations

Precautions to take when operating a total station include:

- Never point the telescope directly at the sun as the sun's rays may damage the diodes in an electronic distance measuring instrument (EDMI).
- If possible, shade the instrument from direct sunlight as excess heat may reduce the range of the sender diodes in the EDM.
- To maintain maximum signal return at longer ranges, shade prisms from direct sunlight.
- Avoid multiple unrelated prisms in the same field of view; this can cause blunders in distance observations.
- Do not transmit with a two-way radio near the total station during EDM measurements.
- Most total stations are equipped to detect and correct various instrumental errors. If such errors exceed program limits, error codes will indicate the error. Consult the operator's manual for exact procedures and error codes.
- Do not carry tripod-mounted instruments over the shoulder.
- Whenever possible, select instrument setup locations to minimize the exposure of the instrument operator, other members of the crew, and the instrument to danger. Select stable ground or footing for the tripod feet. Do not set an instrument directly in front of or behind a vehicle or piece of construction equipment that may suddenly move.
- Don't leave instruments unprotected or unattended.
- In the event that the instrument or any personnel are required to be in an area subject to traffic, protection procedures outlined in Section 2, "Safety," must be followed.

Total Station Survey System Accessories

Prisms: Some guidelines to properly maintain prisms are:

- Transport prisms in separate compartments or containers to minimize damage.
- Clean glass surfaces regularly, using water and a soft towel or specially treated, lens cleaning tissue.

3.5-3 Global Positioning System Instruments

Field components of GPS survey systems include:

- Receivers
- Data collection system
- Antennas
- Radio system for data transfer (for real-time positioning)
- Cables
- Accessories (such as tripods, tribrachs, batteries and chargers, stakeout poles, height hooks, and other miscellaneous accessories)

GPS Receivers

A typical survey-grade GPS receiver is encased in a high-impact plastic housing that is lightweight and weatherproof. The unit is powered by DC power between 10.5 to 35 volts and uses less than 9 watts of power. The unit is compact, portable and is equipped with a display window and keypad for operation.

Check to ensure that the latest revisions to the instrument's firmware have been installed.

Radio frequency energy from nearby radio, television, or radar transmitters may overpower GPS receiver circuits. Attempt to stay at least a quarter of a mile away from such electromagnetic field sources. Low power handheld radio operations may also interfere with operation of a GPS unit.

GPS receivers require line-of-sight reception of the satellite signals and perform best when the antenna has an unobstructed view of the sky.

Antennas and Cabling

Two types of antennas are used with typical GPS units. The geodetic antenna is a high-precision micro strip antenna with a large groundplane used for static GPS surveys. It is mounted on a tribrach and tripod and then precisely centered and leveled over a survey mark or monument for high accuracy GPS measurements. The kinematic antenna, used for kinematic and real-time kinematic GPS surveys, is mounted on a fixed-height range pole and may be supported by a bipod.

Both types of antennas are connected to the receiver by a detachable cable. Care must be taken not to kink or pinch this cable. The antennas are completely sealed and weather resistant, and require no calibration or adjustment. Some antennas have a built-in drying agent. The desiccant should be checked on a regular basis and removed and dried when necessary.

Mixing antennas of different model or make of GPS receiver systems may induce error or damage the units due to voltage mismatches.

Two types of antenna transport cases are available: soft and hard. The soft case is used for normal field operations, while the hard case should be used for extended transport and shipping or extreme field conditions.

3.5-4 Leveling Instruments and Rods

Caltrans survey crews are generally equipped with an optical pendulum level. Electronic digital bar-code levels and matching bar-code level rods are also available for use.

Optical Pendulum Level

Pendulum levels are fast, accurate, and easy to maintain. Proper care and service is required to provide continuous service and to maintain precision in measurement. Never disassemble an instrument in the field. Only make those adjustments outlined in the operator's manual.

Care of a Pendulum Level:

- To prevent compensator damage, do not spin, bounce, or hit pendulum levels.
- Protect the level from dust. Dust or foreign matter inside the scope can cause the compensator damping device to hang up.

Circular Bubble Test and Adjustment: Frequently check adjustment of the bullseye bubble. Adjust the bubble to the center of the bullseye. Make certain the bubble is adjusted along the line of sight and 90° to the line of sight as well. Proper adjustment reduces the possibility of compensator hang-up. Adjustment will be easier if done in the shade, where temperature is constant.

Horizontal Cross-Hair Test and Adjustment (Two-Peg Test): At least once every 90 days or when discrepancies show up in the leveling work and before every three-wire level survey, the “Two-Peg Test” should be performed as follows:

- Select two bench marks “A” and “B” approximately 60 m apart.
- Set up the level midway between the two points “A” and “B” and record the rod readings of each point determining their difference in elevation.
- Move the level 6 m beyond either bench mark and record the rod reading of both points again, once again determining their difference in elevation.
- If the difference in elevation measured at each setup is the same, the level is in adjustment. If not, the horizontal cross-hair should be adjusted as detailed in the operator’s manual.
- After the adjustment repeat the “peg test” again to check the adjustment.

Mechanical Functions: To check for compensator hang-up, lightly tap the telescope with a pencil or operate the fine movement screw jerkily to and fro. If the compensator is slow to respond or malfunctioning, send the instrument to an approved repair service. There are no mechanical field adjustments that can be made on the compensator.

Electronic Digital Bar-Code System

Digital bar-code levels operate by comparing the observed digital image of a bar-code leveling rod with a map of the bar code stored in the level’s memory. These instruments are also equipped with a conventional pendulum-type compensator and may be used as an optical level. An on-board computer processes all leveling operations including determination of sight lengths.

A bar-code system should include:

- Digital level with data recorder module or cable connected data collector
- Data reader and/or appropriate computer interface
- Bar-code leveling rods

Field Operations: At the beginning and end of each day's operation, check the instrument for collimation error, recording the tests into the survey notes. When using electronic digital leveling instruments, the absolute collimation error will be recorded along with the leveling data. If an error in excess of 2 mm within a 60 m sight distance is detected, the level should be readjusted. If the instrument is severely jolted or bumped, or suspected as such, it should be immediately checked.

Manufacturers' specifications state that the electronic digital leveling instrument should not be exposed to direct sunlight and recommend use of an umbrella in bright sunlight.

Horizontal Cross-Hair Test and Adjustment (Two-Peg Test): The test and adjustment procedure for an electronic digital level is geometrically similar to the two-peg procedure for a conventional optical level. However, all horizontal and vertical measurements and differences are measured and recorded electronically. The collimation error is recorded by the on-board computer.

Data Collection, Storage, and Transfer: Raw data generated by an electronic digital level is stored in a data collector and processed into field book format. Software will perform simple or least-squares adjustment of the data. An ASCII file may be created that can be imported into road design software.

Leveling Rods

Leveling rods should be maintained and checked as any other precision equipment. Accurate leveling depends as much on the condition of the rods as on the condition of the levels. Reserve an older rod for rough work, such as measuring inverts, mud levels, water depths, etc.

Routine Maintenance and Care: Maintenance procedures common to all types of rods are:

- Periodically lubricate hardware and slip joints with an oil-free silicon spray.
- Clean sand and grit from slip joints.
- Clean graduated faces with a damp cloth and wipe dry.
- Keep the base plate clean.

- Periodically check all screws and hardware for snugness and operation.
- Periodically check accuracy by extending rod and measuring between graduations across rod section divisions with an accurate tape.

Transport and Storage:

- If possible, leave a wet rod uncovered and extended until it is thoroughly dry.
- Store rods in protective sleeves or cases, in a dry location, either vertically (not leaning), or horizontally. When stored horizontally, either fully support the rod or provide at least three-point support.

Field Operations:

- Touch graduated faces only when necessary and avoid laying the rod where the graduated face will come into contact with other tools, objects, or materials that could mar the face.
- Do not abuse a rod by throwing, dropping, dragging, or placing it where it might fall.
- Do not lay a rod in sand, dust, or loose granular material.
- Lower rod sections as the rod is being collapsed. Do not let them fall or drop.

Direct Reading Rod: At frequent intervals, check all components for wear. Periodically lubricate all hardware, racks, and rollers with a oil-free silicone aerosol spray. If the tape guides begin to snag or bind the tape, have the rod repaired.

Fiberglass Leveling Rod: Dowels through the bottom of each section keep the section above from falling inside the lower section. Dropping the sections when collapsing the rod will loosen the dowels causing the sections to jam and may also shatter the fiberglass around the dowel holes.

Observe the following precautions:

- When the slip joint goes bad, remove the rod from service.
- Lubricate fiberglass rods with an oil-less silicone spray or with talcum.

Invar Leveling Rods: Invar rods are precisely made and standardized; extra care is required to maintain this precision. Observe the following precautions:

- Store, fully supported and stopped, in a water-proof case.
- Do not use invar rods in rain or dust.
- Carry parallel with the ground, in alternate “face-up” and “face-down” positions to equalize weight stresses.
- Avoid laying an invar rod on the ground.
- If foreign matter has “fouled” a rod, carefully disassemble and clean.
- The rod tape must slide freely in the recessed guides as the wooden staff swells or shrinks.

Bar-Code Leveling Staffs (Rods)

A typical bar-code leveling staff is of a different design and construction than a conventional level rod. Several types of bar-code rods are available, depending on the type of work performed. Designs range from an aluminum/invar-tape, precise staff to various sectional staffs constructed of either wood, aluminum, or fiberglass.

Care and maintenance of these staffs is minimal due to their simplistic construction. Store in clean, dry condition and always transport in carrying cases.

3.5-5 Survey Instrument Accessories

Tripods: Tripods support and provide a fixed base for all types of surveying instruments. The typical tripod used for Caltrans Surveys has a 5/8-in. x 11 thread fastener to secure an instrument or accessory to the tripod head. The head provides a lateral adjustment range for the instrument of approximately 25 mm. The tripods are of a wide-frame design and have extendible legs.

A secure and stable tripod is required for the support of precision instruments. There should be no slack between the various components of a tripod. Loose joints or fittings will cause instability.

Some guidelines to properly maintain tripods are:

- Maintain a firm snugness in all metal fittings. Over-tightening is the cause of crushed wooden components and stripped threads.
- Tighten leg hinges just enough to support the fully extended legs when a tripod is lifted clear of the ground.
- Keep the metal tripod shoes tight and free of dirt and debris.
- Keep wooden parts of tripods well-painted or varnished to reduce swelling and shrinking due to moisture content of the wood.
- Always replace top caps when tripod is not in use to protect the mounting surface and head from damage.
- Use care when placing or removing tripods from the survey vehicle, as significant damage can occur. Ensure that carry compartments are designed and constructed to isolate tripods from each other and from other equipment.

Tribrachs: Tribrachs are the detachable base for most survey instruments and many accessories. They are equipped with an optical plummet and spherical “bullseye” level. The ability to “leapfrog” instrument setups by interchanging instruments, prisms, targets, or antennas without disturbing the setup of a tribrach greatly enhances the speed, efficiency, and accuracy of a survey.

Some guidelines to properly maintain tribrachs are:

- Transport tribrachs in separate compartments or containers to prevent damage to the base surfaces, spherical level and optical plummet.
- Do not over-tighten the tripod fastener screw.
- Clean leveling screws regularly.
- When tribrachs are not in use, set leveling screws at mid-range, usually marked by a horizontal line.
- Use care whenever using range poles mounted on a tribrach to vertically extend a sight, antenna, or prism. Extensions place considerable stress on the leveling plate.
- Adjust spherical level and vertical collimation of optical plummet routinely.

Prism Poles/Antenna Poles: An attached adjustable spherical level bubble (bullseye) is used to maintain a prism/antenna pole in a vertical position. A maladjusted level bubble may cause systematic error when using the pole. A simple method for checking the accuracy of the bullseye bubble is to check the rod by placing it against a door jamb or other permanent vertical part of a building that has been previously verified as being vertical.

3.6 Computer Systems

To effectively process the large volume of electronic data produced by Caltrans survey crews, each Surveys office should be equipped with adequate desktop computing, storage, and printing equipment. The number of computer modules will be predicated on the workload and staffing of a specific office.

3.6-1 Office Computer Systems

Each Surveys office employee should have access to a personal computer with sufficient processing and memory capability to fully utilize currently supported design/survey processing software. Computers should be supplied with Caltrans standard business software (word-processing, spreadsheet, and communications) approved by Caltrans Information Technology (IT) and surveying software supported by the Office of Geometronics. Each computer should be connected to the Caltrans Wide Area Network to take advantage of information available on the Caltrans Intranet and the Internet and network peripherals (printers, mass storage, scanners).

3.6-2 Field Computer Systems

Each survey party should be equipped with a laptop personal computer and a printer. The computer should have processing and memory capability to fully utilize supported surveying software provided by the DES/Office of Geometronics. Also, business software (word-processing, spreadsheet, data base and communications) approved by Caltrans Information Technology (IT) should be provided. Each computer should have the capability to connect to the Caltrans Wide Area Network to take advantage of information available on the Caltrans Intranet and the Internet, send and receive survey data to and from the Surveys office, and access network peripherals (printers, mass storage, scanners).

3.6-3 Computer Procurement

In addition to normal procurement procedures, acquisition of computers or computer related equipment requires that a Workgroup Computing Justification Form (Form DIS 050) be completed. Section III of the form may be completed and used in lieu of a local request.

Survey party computer systems are generally obtained by the Office of Geometronics. For information on upgrades and service and repairs, contact the Office of Geometronics.

3.6-4 Caltrans Policy Regarding Use of State Computer Systems

Use of Caltrans computer equipment for personal business is subject to adverse action. For more detailed information on this policy, see the current Directors' Policies and Deputy Directives concerning computer usage and information technology.

3.7 Vehicles

Care and operation of State-owned vehicles are detailed in the Department's *Equipment Manual* and in Board of Control rules. Many of the Equipment Manual instructions, especially those dealing with operation and emergency service, are summarized in the booklet, *Operation, Accident and Emergency Service Information*. This booklet is in the "Vehicle Accident Reports" envelope in the glove compartment of all State vehicles. All employees who drive State-owned vehicles should familiarize themselves with the contents of this booklet.

The appropriate Hourly Vehicle Log or Mileage Vehicle Log and the Daily Pre-Operation Report must be completed each day that a vehicle is used.

Vehicle operation and care are joint responsibilities of all survey field crew members. Some of these responsibilities are:

- Use of seat belts by all.
- Use of defensive driving techniques.
- Observance of all State and local vehicle regulations.
- Operation within the physical and mechanical limitations of the vehicle.
- Compliance with the Preventative Maintenance (PM) policies.

Guidelines for safe motor vehicle operation are found in Chapter 17, “Motor Vehicle Safety” of the *Caltrans Safety Manual*.

3.7-1 Misuse of Vehicles

Use of a State owned vehicle for personal business is subject to adverse action. For details see Section 17.12, “Misuse of State-owned Motor Vehicles” of the *Caltrans Safety Manual*.

3.7-2 Home Storage of State Vehicles

Home storage of Caltrans vehicles is permitted in cases when secure Caltrans storage for vehicles is not available and when it is more efficient to store vehicles at home so that employees can begin the workday at the job site. Home storage is not allowed to enable employees to commute in State-owned vehicles. A Home Storage Permit is required for employees on State business who drive and store a State vehicle at home at least 36 nights in three months or 72 nights in one year. To obtain applications and requirements for Home Storage Permits, contact the District Automotive Manager. Permits must be reviewed for renewal on an annual basis.

3.7-3 Security of Vehicles

The operator or user of a State vehicle is responsible for the security of the vehicle and its contents when parking or storing it. The following security precautions should be followed:

- Remove ignition keys; close and lock all windows, doors, and compartments.
- Conceal valuable survey and other equipment. All such equipment should be stored out-of-sight, or taken into the overnight quarters.
- Park off the street whenever possible. In residential areas you must park off the street unless specifically authorized to do otherwise.
- Leave vehicle in “low” or “reverse” in manual transmissions, or “park” in automatic transmissions and with the emergency brake firmly set. If parked on a grade, turn the front wheels to roll into the curb or off the road.

3.7-4 Off-Road Operations

Four-wheel-drive vehicles are equipped for use in rough terrain or adverse driving conditions that make travel in two-wheel drive vehicles hazardous or impossible. Some guidelines for the proper use of four-wheel-drive vehicles are:

- Do not wait until there is a problem to use four-wheel drive (see note).
- Make certain the transfer case and the front drive hubs are engaged (see note).
- Do not engage the low range without having the hubs in locked positions (see note).
- Keep your speed below 25 mph when in four-wheel drive.
- Do not drive on pavement in four-wheel drive (see note).
- Avoid side-hill operations.
- Secure all equipment before traveling on rough or difficult terrain.

Note: Not all four-wheel-drive vehicles operate in the same manner. Consult the operator's manual for appropriate operation of a particular make and model of vehicle.

3.7-5 Obtaining Fuel, Service, and Parts

Whenever feasible, fuel, service, and parts must be obtained from a State facility or contractor. Make an effort when purchasing fuel, service, and parts from a commercial facility to obtain the lowest possible cost for the state.

Purchases from commercial vendors for State vehicles should be made using the State gas credit card. Before using the State gas credit card, check for acceptance prior to delivery of the product or service. The operator of a State vehicle must assure proper credit card usage through the following actions:

- Make sure the license number of the vehicle, along with a complete itemization of all services and/or products that are delivered by the vendor, are recorded on the credit card charge ticket.
- Submit written justification, along with the charge ticket and the itemization of charges, for any emergency purchases.

Consult with the Equipment Shop or traveling mechanic by telephone or radio before committing the State to emergency purchases. Submit written justification, along with the receipt or invoice of charges, for any emergency purchases. Generally, emergency purchases are permitted if:

- The Equipment Shop does not stock the item or does not have it in stock.
- The Equipment Shop does not or cannot provide the needed service.
- The expense of traveling, time and distance, to the State shop is less economical than making an emergency purchase.
- Travel is required during hours that the State shop is closed.

In emergency situations, if products or services cannot be obtained through the credit card, the employee may pay cash. For reimbursement submit a Cash Expenditure Voucher, Form FA-202, including justification for the purchase, accompanied by a receipt from the vendor.

3.7-6 Preventive Maintenance

Preventative maintenance is a regularly scheduled program of checks, inspections, and services designed to ensure minimum downtime and to prevent unsafe or untimely equipment failures.

A program of preventive maintenance (PM) shall be followed for each survey vehicle. This program and pertinent procedures are covered in the Equipment Service Center's July 1, 1995 memo revising the July 13, 1994 *Mobile Equipment Preventive Maintenance Guidelines*.

The PM program includes:

- Daily pre-operation inspection and reporting using the Daily Pre-operation Inspection Booklet (DME - 151).
- Regular preventive maintenance inspections at least every six months.
- Use of the Permanent Equipment Maintenance Record Book for all vehicles.

3.7-7 Using Privately-Owned Vehicles for State Business

Use of privately-owned vehicles on State business may be permitted if advantageous to the State or if a State vehicle is unavailable. For instructions and rules for the use of privately-owned vehicles for State business, see the *Caltrans Travel and Expense Guide*, Section III, “Private Vehicle Use.”

Advance authorization is required for use of a privately-owned vehicle on State business. Authorization is obtained by filing Form FA 205, “Authorization To Use Privately-Owned Automobiles on State Business.” This form must be filed yearly.

Privately-owned motorcycles are not authorized for use on State work.

3.8 Radio Communication Systems

Good communications are essential to efficient and safe surveys operations. Surveys employees must utilize the Caltrans radio communications system properly, as the system is operated under a license from the Federal Communication Commission (FCC). Violation of FCC rules could result in loss of frequency privileges.

The primary statewide system consists of more than 10,000 mobile units and some 1300 base stations. (Mobile units include radio-equipped vehicles and portable, hand-held radios). It is classified as a mobile radio system. Base stations are usually located at district offices and the offices of maintenance superintendents and resident engineers. Transmitters and repeater stations are located on mountain tops to obtain greater range.

Survey field crews use the statewide mobile radio system for communication with the District Surveys office, other field crews, and individuals on the same crew. Shorter range hand-held radios are preferred for communication between members of the same survey crew. Due to frequency mismatches, some vehicle-mounted mobile radios cannot interact with the hand-held radios.

For more detailed information on the Caltrans radio system, see the *Caltrans Radio Operator's Manual*.

3.8-1 Purchase and Service

Caltrans radio equipment is obtained and serviced by the Caltrans Telecommunications Section. Contact the District Telecommunications Manager to obtain new systems or when existing systems require service.

Do not automatically assume that your radio is at fault when you are unable to communicate with a desired station. The other radio, associated control equipment, or repeater station might be defective. Also, the operator of the other radio might be temporarily away from the radio; you could be out of range or in a “dead” spot; or the other radio might be turned off.

3.8-2 Transport and Storage

Radios should be kept in their carrying case at all times. Avoid laying a radio in precarious places where it could be dropped or knocked to the ground. Never pick-up a hand-held radio by its rubber antenna. Also, do not clip the microphone to its antenna.

3.8-3 Field Operations

Precautions to be taken when using radios are:

- All messages should be as short and to-the-point as possible.
- Trade off hand-held radios so that one is not used exclusively for transmitting, as lengthy transmissions require considerably greater battery discharge than receiving only.
- Battery life of the receiving hand-held radio can be extended by simply clicking the transmission button to acknowledge receipt of a message.
- Portable radios should never be left laying in direct sunlight for extended periods of time.
- Radio transmissions should never take place near total station or GPS instruments while measurements are in progress as data may be corrupted.
- Never transmit near blasting operations without first receiving clearance from the person in charge.

- Speak in plain language at a moderate rate, using words with a clear definition, while holding the microphone close to, but not touching, the mouth.
- Pause and listen before you push the transmit button.
- Do not break into ongoing conversations unless your transmission is an emergency.

3.8-4 Improving Radio Transmission Quality

Radios do not always work equally well in all directions. Because of terrain or obstructions, radio transmissions may be directional. If you are unable to communicate with a desired station (unit), try the following:

- Turn your radio to face another direction.
- Change location (sometimes only a few yards helps).
- Move to a higher elevation (an overpass can sometimes help).